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ACL injuries in American Football: Mechanisms, Diagnostic Methods, and Preventive Strategies

Hetong Zhang

Beijing University of Chinese Medicine, Beijing, China

20230941512@bucm.edu.cn

Abstract. American football, with a history spanning nearly 200 years, is known for its high entertainment value and significant fitness benefits, particularly in North America. In recent years, the sport has seen increasing popularity in China, drawing more young athletes to participate. However, the sport's physical demands increase the danger of injury, particularly anterior cruciate ligament (ACL) injuries, which are among the most prevalent and severe. This article seeks to give a complete examination of ACL injuries in American football players by looking at their prevalence and causes. It explores key diagnostic methods used to assess ACL damage, such as the Lachman test and axial displacement test, and highlights the importance of early and accurate diagnosis. Additionally, the article discusses various prevention strategies, including strength training and neuromuscular conditioning, aimed at reducing the occurrence of ACL injuries. The review also covers post-surgical rehabilitation, outlining exercises and protocols that facilitate recovery and prevent reinjury, ensuring athletes can safely return to the field.

Keywords: American football, ACL injuries, Rehabilitation training.

1. Introduction

American football is one of the most popular sports in the USA, renowned for its high-intensity, full-contact nature. The National Football League (NFL) is the largest professional sports league in the country, with millions of dedicated fans and substantial financial influence, reaching billions of dollars in total assets [1]. In 2018, a Gallup study indicated that 37% of Americans chose football as their favorite sport, greatly surpassing basketball, which garnered 11% of the vote [2]. The annual Super Bowl consistently attracts hundreds of millions of viewers worldwide, solidifying football’s cultural impact [3]. In recent years, American football has also gained traction in China, with universities establishing teams and leagues as part of a growing movement to promote the sport [4, 5]. Despite its popularity, the sport’s physically demanding nature exposes players to considerable risks of injury, particularly in the knee joint.

The anterior cruciate ligament (ACL) is a vital component that stabilizes the knee joint. Originating from the anterior medial aspect of the tibial intercondylar eminence and attaching to the lateral condyle of the femur, the ACL functions to prevent excessive forward translation and rotation of the tibia relative to the femur. It plays a crucial role in maintaining knee joint stability during high-intensity movements such as running, pivoting, and jumping, all of which are integral to American football. Given the explosive and rapid directional changes inherent to the sport, ACL integrity is essential to athlete performance.

ACL injuries are one of the most prevalent and debilitating injuries in American football. Epidemiological studies indicate that knee injuries account for a substantial proportion of all injuries in the sport, with ACL tears being particularly prevalent. Studies report that 22% to 39% of professional football players experience severe knee injuries [6], with ACL tears ranking second among the most common injuries sustained by athletes [7-9]. Non-contact ACL injuries, typically occurring during sudden deceleration, pivoting, or landing, make up a significant portion of these cases [10-15]. This high incidence underscores the necessity for a comprehensive understanding of the mechanisms, risk factors, and preventative strategies to mitigate these injuries and safeguard athletes' long-term health.

2. Reasons for ACL injuries in American football

The incidence of non-contact ACL injuries in American football is notably high. Long-term studies tracking the medical histories of American football players have revealed that 72% of ACL injuries occur during sudden braking, deceleration, or landing, all in non-contact situations [14-17]. Epidemiological research further supports this finding, showing that 6% to 9% of ACL injuries in athletes result from high-speed directional changes [10]. A survey of young American football players under the age of 20 found that 8.9% experienced ACL injuries during high-speed turns [11]. Scott et al. [12] observed that lateral cutting movements are strongly associated with ACL injuries, particularly those involving sudden changes in direction. Similarly, Boden studied 82 athletes with non-contact ACL injuries and found that 17 cases were linked to rapid directional changes during exercise [13].

Furthermore, numerous studies have highlighted that an imbalance in strength between the hamstrings and quadriceps is a significant factor that contributes to ACL injuries. The ratio of muscle activation between these muscle groups is crucial for maintaining athletic performance and preventing injury in American football players.

3. ACL injury examination

3.1. Front drawer test

In this test, the patient lies supine with their knees bent at 90 degrees and feet flat on the bed. The examiner stabilizes the foot of the tested leg by sitting on it. Using both hands, the examiner grasps the tibial plateau and moves the calf forward. A positive result is indicated by the absence of a terminal sensation or excessive forward movement compared to the opposite side. An ACL rupture typically allows for forward displacement of more than 0.5 cm.

3.2. Lachman test

The patient lies supine with knees bent approximately 30 degrees and the calves slightly rotated outward. In this examination, the patient lies on their back with their knees bent at a 90-degree angle and their feet flat on the bed. The examiner stabilizes the foot of the tested leg by sitting on it. The examiner holds the thigh near the knee with one hand and places the other hand behind the tibia, with the thumb on the tibial tuberosity. The examiner then pulls the tibia forward. A healthy ACL prevents the forward movement of the tibia, resulting in a distinct end-feel. A positive test result is indicated by the absence of this end-feel and a forward displacement of more than 2 mm compared to the healthy side, suggesting an ACL tear.

3.3. Axial displacement test

For this test, the patient lies supine with both legs relaxed. The examiner holds the affected foot with one hand, rotates it internally, and fully extends the knee joint. The examiner then applies force to make the knee joint turn outward and finally flexes the knee joint. A positive result is indicated if the dislocated tibia, when flexed between 30° and 40°, exhibits noticeable rebound. This finding suggests an abnormality in the ACL, which may be accompanied by other pathological changes.

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3.4. Leverage test
In this test, the patient is positioned supine with the knee fully extended and the heel in contact with the bed. The examiner clenches their fist and places it below the proximal tibial tuberosity of the affected leg. When slight downward pressure is applied to the quadriceps tendon, the examiner checks whether the heel can "lift." If the heel does not lift, the test is considered positive, indicating a possible ACL injury.

4. Common treatments for ACL injuries

4.1. Non-surgical treatment
For patients with partial ACL tears and low physical activity demands, non-surgical treatment options can be effective. This approach typically includes rest, immobilization, and physical therapy. Knee joint braces are often used for fixation, which may last 4 to 6 weeks, combined with rehabilitation exercises to facilitate recovery of knee function.

4.2. Surgical treatment
Surgical intervention is commonly recommended for most patients with complete ACL ruptures. Arthroscopic ACL reconstruction is the standard surgical procedure, during which either autologous or allogeneic tendons are used as grafts to replace the damaged ligaments. The surgery generally lasts 1 to 2 hours.

4.3. Postoperative rehabilitation
Postoperative rehabilitation is crucial for recovery. Early range of motion exercises, such as knee flexion and extension, should begin 1 to 2 weeks after surgery to gradually increase the knee's range of motion. Muscle strength training typically starts 2 to 3 months post-surgery with activities like weight-bearing walking. The entire rehabilitation process can take 6 to 12 months. Psychological support is also important, as patients may experience significant stress and concern about regaining full knee function. Effective communication and psychological intervention can enhance rehabilitation outcomes and improve quality of life.

5. Training for preventing ACL injuries
Preventing ACL injuries primarily involves enhancing the strength and flexibility of the muscles surrounding the joints. In training, the initial focus for athletes should be on improving joint mobility and control of lower limb posture and movement without inducing muscle fatigue [16]. This includes performing exercises that emphasize correct technical posture. Stretching before and after training is crucial, as it ensures that antagonistic muscles are fully stretched. Inadequate stretching can adversely affect muscle function and performance, thereby increasing the risk of injury. Thus, particular attention should be given to stretching the muscles around the knee joint. Anatomically, the knee joint serves as both the origin and insertion point for several lower limb muscles. Proper function of the knee joint is essential for maintaining the normal function of adjacent joints and ensuring the correct alignment of the lower limb power chain.

In clinical rehabilitation, lower limb exercises frequently emphasize quadriceps strength training. Additionally, preventing ACL injuries involves addressing knee joint stability through various exercises, including closed-chain and open-chain exercises [18]. Early stages of rehabilitation should incorporate knee stability exercises and range of motion activities, especially for athletes whose training focuses on lower limb movements. Initial exercises might include squats and pelvic movements. Rebecca recommended several exercises: (1) single-leg squats, (2) front lunges and knee bends, (3) toe touches while bending down, (4) lateral sliding steps, (5) glute bridges, and (6) proprioceptive neuromuscular facilitation (PNF) exercises [19].

Liu Hui et al. demonstrated that four weeks of knee resistance training can increase the flexion angle during knee joint movements, thereby reducing the impact of ground forces on the knee [20]. Other studies have shown that proprioceptive training can significantly lower the risk of knee joint injuries in football players [21]. The flexion angles of the hip and knee joints are clinically significant in relation to non-contact ACL injuries in athletes. Tsai highlighted that systematic rehabilitation exercises can significantly reduce the peak torque of the hip, knee, and tibiofemoral joints, thereby effectively decreasing the likelihood of ACL injuries [20].

6. Conclusion

In conclusion, research both domestically and internationally has highlighted the high risk of ACL injuries in American football. Systematic rehabilitation training has proven effective in reducing the risk of ACL injuries and aiding in injury recovery. To achieve optimal injury prevention, preventive rehabilitation training plans must be integrated with daily training routines and require long-term commitment from athletes.

Effective ACL injury prevention plans should include components such as muscle strength training, neuromuscular control, proprioceptive training, and balance exercises targeting both anterior and posterior muscle groups of the lower limbs. Currently, there is a lack of comprehensive and standardized rehabilitation protocols specifically designed for preventing knee joint sports injuries, as well as effective evaluation metrics to assess the success of these preventive measures.

Therefore, sports rehabilitation therapists need to develop tailored training plans for each athlete based on their individual physical conditions. Regular lower limb exercise assessments should be conducted to make timely adjustments to the training plans, ensuring they remain effective and relevant to each athlete's needs.

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